FIG. 1

FIG. 2(a)

FIG. 2(b)

FIG. 3

FIG. 4(a)
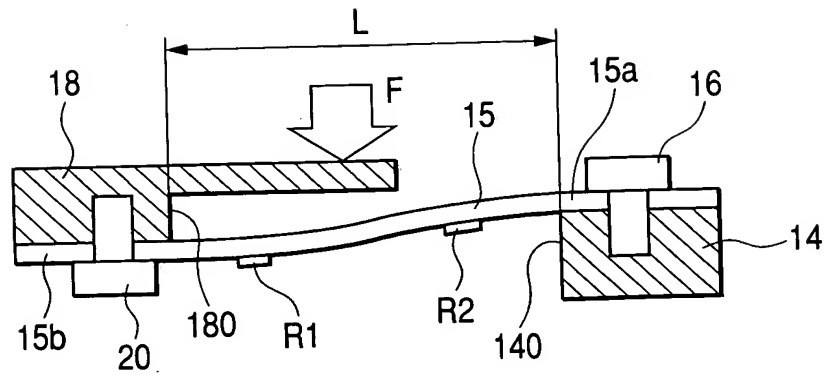
FIG. 4(b)
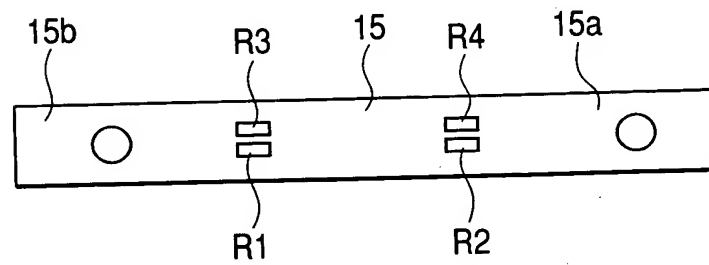
FIG. 4(c)

FIG. 5(a)
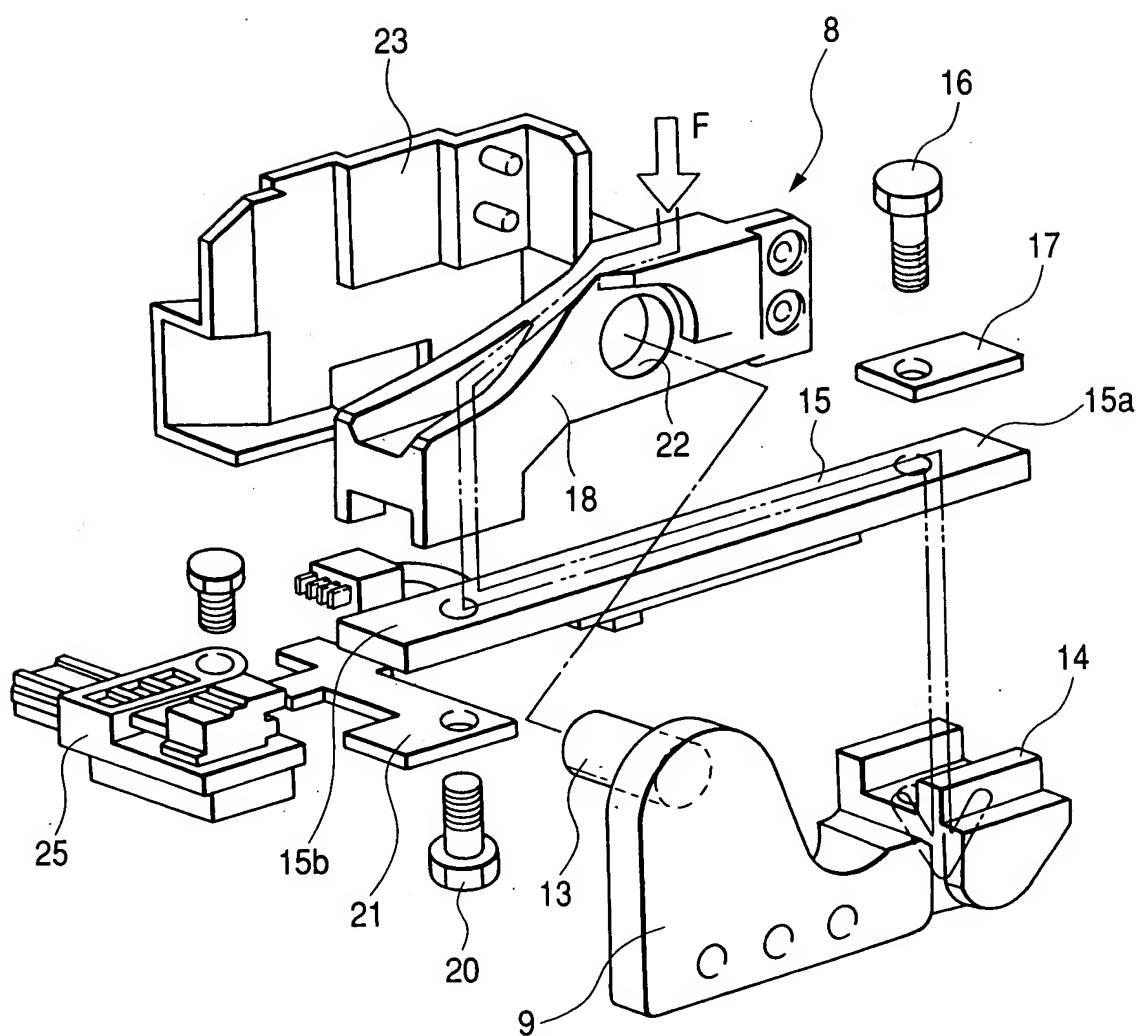
SAME DIRECTIONAL FRONTWARD ORIENTATION

BENDING MODE OF SENSING PLATE

OFFSET LOAD APPLIED MODE

S-CURVE MODE
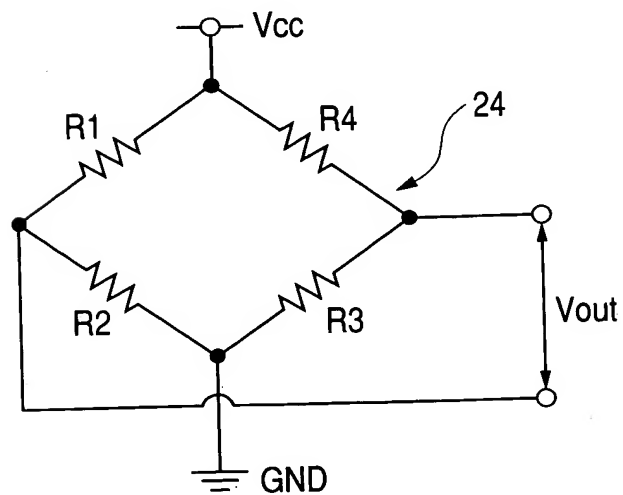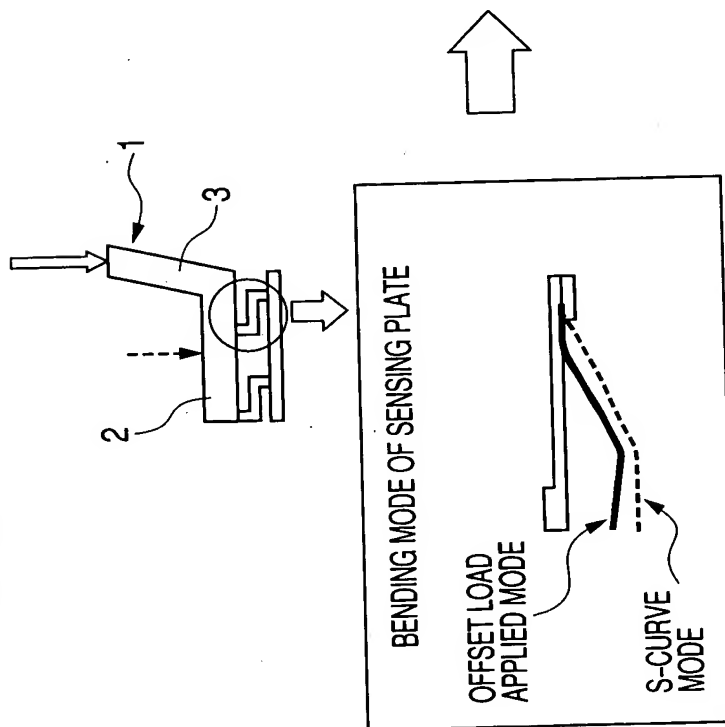
FIG. 5(b)

RELATION BETWEEN STOPPER LOCATION AND STOPPER DISPLACEMENT IN OFFSET LOAD APPLIED MODE

UPPER ARM

LOWER ARM

SENSING PLATE

STOPPER (STOPPER HOLE)

NO LOAD APPLIED

OFFSET LOAD APPLIED

S-CURVE MODE

βL IS DISTANCE BETWEEN STOPPER AND END OF SENSING PLATE

FIG. 6

TABLE I

BENDING MODE AND DYNAMIC MODEL UPON APPLICATION OF OFFSET LOAD

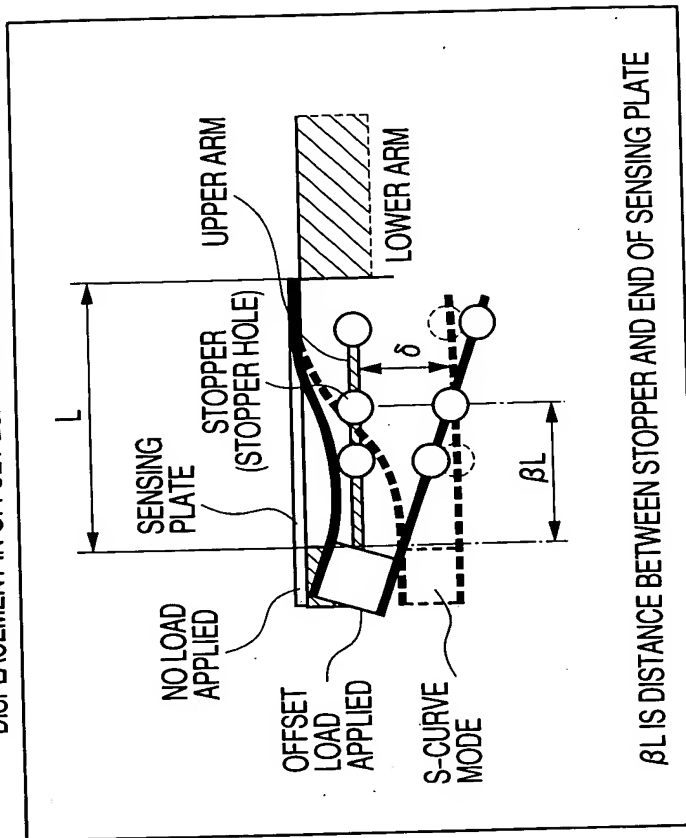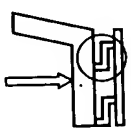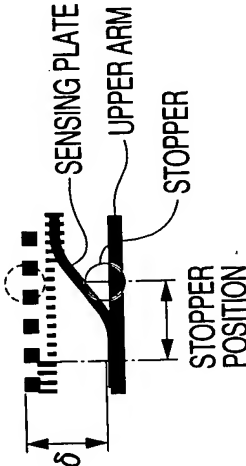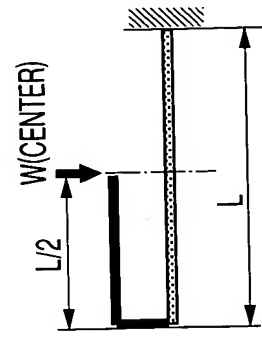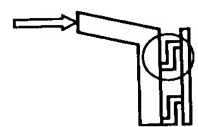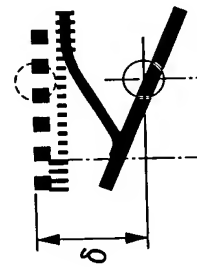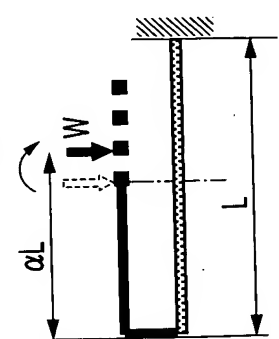|	APPLIED MODE OF LOAD	BENDING MODE	DYNAMIC MODEL CAUSING BENDING AS ILLUSTRATED LEFT
IDEAL S-CURVE BENDING	CUSHION-LOADED MODE	STOPPER DISPLACEMENT — SENSING PLATE, UPPER ARM, STOPPER, STOPPER POSITION, δ	W(CENTER), L/2, L
OFFSET LOAD BENDING	SEAT BACK-LOADED MODE	INPUT OF GREAT ROTATION MOMENT TO SENSING PLATE, δ	SHIFT BY ROTATION MOMENT TO FIXED END SIDE, αL, W, L

FIG. 7

TABLE II

SENSOR INSTALLED ORIENTATION AND BENDING MODE UPON APPLICATION OF OFFSET LOAD

----- IDEAL S-CURVE   —— NONIDEAL CURVE
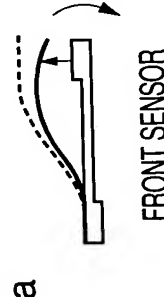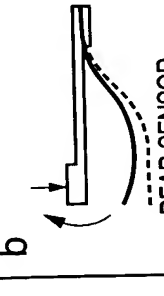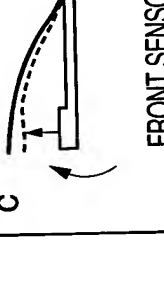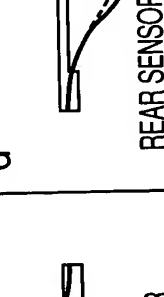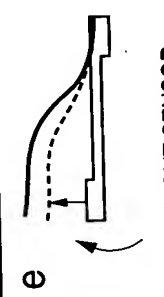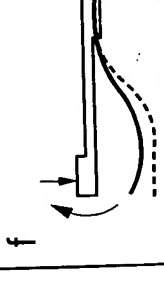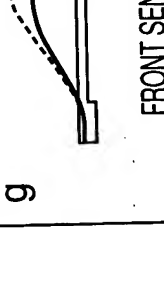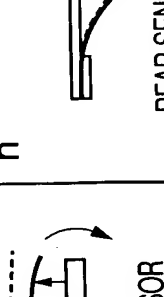
FIG. 8

STOPPER DISPLACEMENT EQUATION

$M(x)=Wx-\alpha LW \cdots (1)$

$\dfrac{d^2y}{dx^2} = \dfrac{-M}{EI} = \dfrac{W}{EI} (\alpha L-x)$

ANGLE OF INCLINATION OF SENSING PLATE

$Ik(x) = \dfrac{dy}{dx}$

$= \dfrac{W}{2EI} \{-x^2+2\alpha L \cdot x+(1-2\alpha)L^2\} \cdots (2)$

DISPLACEMENT OF SENSING PLATE
(EXPRESSED BY POSITIVE VALUE IN DOWNWARD DIRECTION)

$Yk(x) = \int Ik(x) \, dx$

$= \dfrac{(-W)}{6EI} \{-x^3+3\alpha L \cdot x^2+(3-6\alpha)L^2 \cdot x+(3\alpha-2)L^3\} \cdots (3)$

FIG. 9(a)

STOPPER DISPLACEMENT
EQUATION
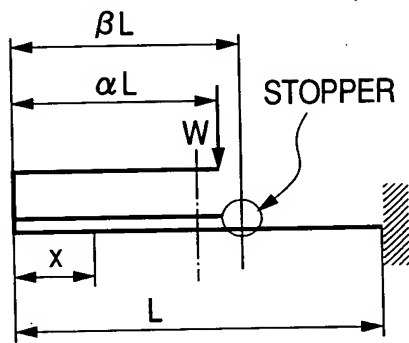
βL: APPLIED LOCATION OF LOAD
αL: STOPPER POSITION
Ys: STOPPER DISPLACEMENT

$$Ys = Yk\,(x=0) + \delta$$
$$= Yk\,(x=0) + \beta \cdot L \cdot \tan\{Ik\,(x=0)\}$$
$$= \frac{WL^3}{6EI}\{(2-3\alpha)-3\beta(1-2\alpha)\} \cdots(4)$$

$$\sigma\max = \frac{M\max}{Z} = -\frac{\alpha LW}{Z} \cdots(5)$$

$$Ys = \frac{L^2}{3\alpha Et}\{(2-3\alpha)-3\beta(1-2\alpha)\}\cdot\sigma\max \cdots(6)$$

$$Ys = \frac{2L^3}{Ebt^3}\{(2-3\alpha)-3\beta(1-2\alpha)\}\cdot W \cdots(7)$$

FIG. 9(b)

STOPPER DISPLACEMENT
EQUATION
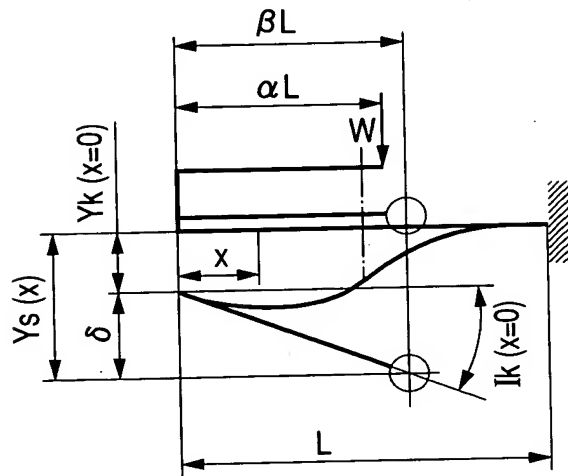
FIG. 10

TABLE III

BENDING MODE		STOPPER DISPLACEMENT -TO-POSITION RELATION
IDEAL S-CURVE BENDING MODE	CENTER LOAD	Ys: STOPPER DISPLACEMENT Yk: MOVABLE END DISPLACEMENT $Ys=Yk(x=0)$ STOPPER DISPLACEMENT IS INDEPENDENT OF STOPPER POSITION
OFFSET LOAD APPLY MODE — FIXED END OFFSET LOAD APPLY MODE	FIXED END SIDE LOAD	δ: STOPPER DISPLACEMENT RESULTING FROM INCLINATION OF MOVABLE END $Ys=Yk(x=0)+\delta$ $=Yk(x=0)+Ls \cdot \tan[Ik(x=0)]$ STOPPER DISPLACEMENT DEPENDS ON STOPPER POSITION
OFFSET LOAD APPLY MODE — MOVABLE END OFFSET LOAD APPLY MODE	MOVABLE END SIDE LOAD	$Ys=Yk(x=0)-\delta$ $=Yk(x=0)-Ls \cdot \tan[Ik(x=0)]$ STOPPER DISPLACEMENT DEPENDS ON STOPPER POSITION

FIG. 11(a)

STOPPER ALLOWABLE CLEARANCE EQUATION

$0 \leqq \beta \leqq 1/2$

$\beta = 3/10$

UPPER LIMIT δu

STOPPER DISPLACEMENT Ys [mm]

MAX. BENDING STRESS σ max [kgf/mm²]

ALLOWABLE CLEARANCE Yt

$\delta u = \dfrac{L^2}{2Et} \cdot \beta \cdot \sigma e \cdots (6, 1)$

$\delta u - \delta l = Yt = \dfrac{L^2}{2Et} \cdot \sigma e \cdot \beta - \dfrac{L^3 \cdot W1}{Ebt^3} \cdots (8)$

$\delta l = $ STRESS LIMIT

FIG. 11(b)

→◇— IDEAL S-CURVE $\alpha = 1/2$

—□— OFFSET LOAD CURVE $\alpha = 2/3$

$\beta = 3/10$

LOWER LIMIT δl

STOPPER DISPLACEMENT Ys [mm]

APPLIED LOAD [kgf]

$\delta l = \dfrac{L^3 \cdot W1}{Ebt^3} \cdots (7, 1)$

W1 = LOWEST LOAD IN LOAD MEASUREMENT RANGE

FIG. 12(a)

STOPPER ALLOWABLE CLEARANCE EQUATION

◇ IDEAL S-CURVE $\alpha=1/2$
☐ OFFSET LOAD CURVE $\alpha=2/3$

$1/2 \leq \beta \leq 2/3$

$\beta=3/5$

STOPPER DISPLACEMENT Ys [mm]

UPPER LIMIT δu

ALLOWABLE CLEARANCE Yt

MAX. BENDING STRESS σ max [kgf/mm²]

$\delta u = \dfrac{L^2}{2Et} \cdot \beta \cdot \sigma e \cdots (6, 2)$

$\delta u - \delta l = Yt = \dfrac{L^2}{2Et} \cdot \beta \cdot \sigma e - \dfrac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \cdots (9)$

$\delta l = $ STRESS LIMIT

FIG. 12(b)

$\beta=3/5$

STOPPER DISPLACEMENT Ys [mm]

LOWER LIMIT δl

APPLIED LOAD [kgf]

$\delta l = \dfrac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \cdots (7, 2)$

W1 = LOWEST LOAD IN LOAD MEASUREMENT RANGE

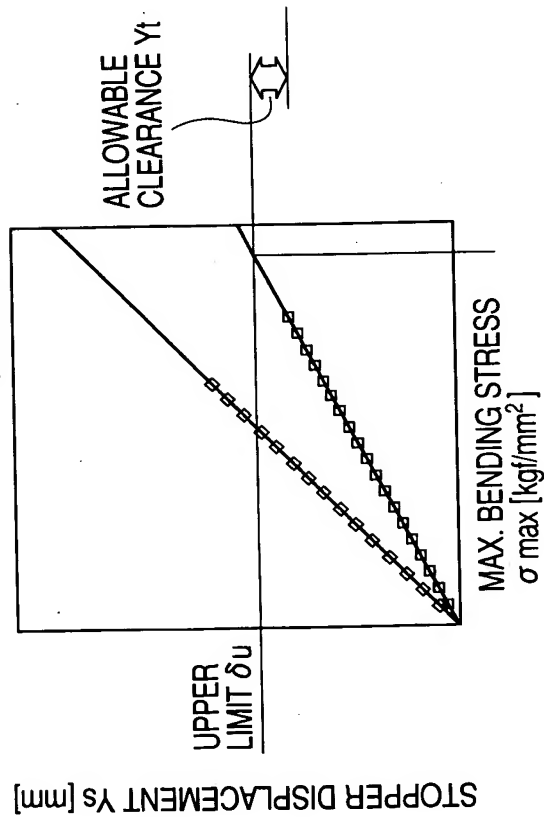# FIG. 13(a)

STOPPER ALLOWABLE CLEARANCE EQUATION

◇— IDEAL S-CURVE $\alpha = 1/2$
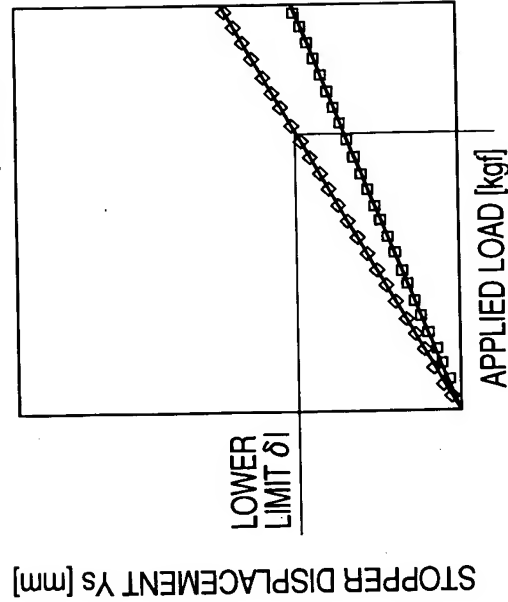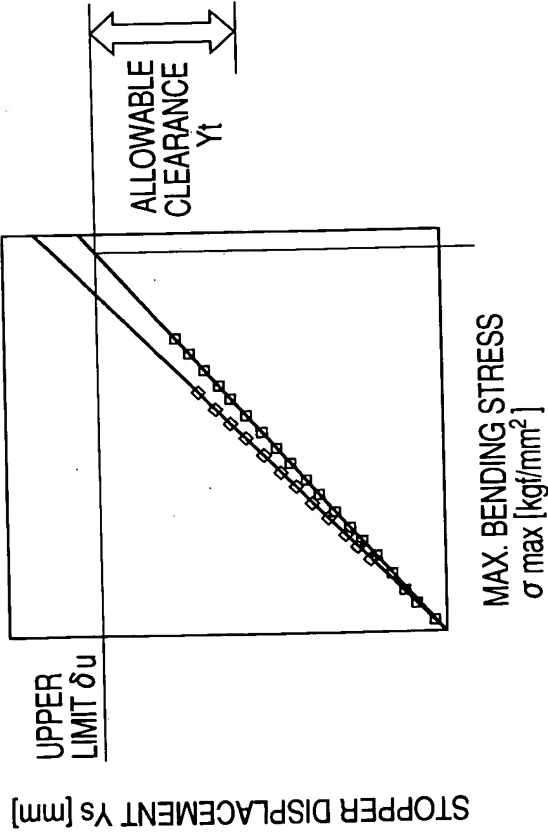□— OFFSET LOAD CURVE $\alpha = 2/3$

$\beta \geq 2/3$

$\beta = 4/5$

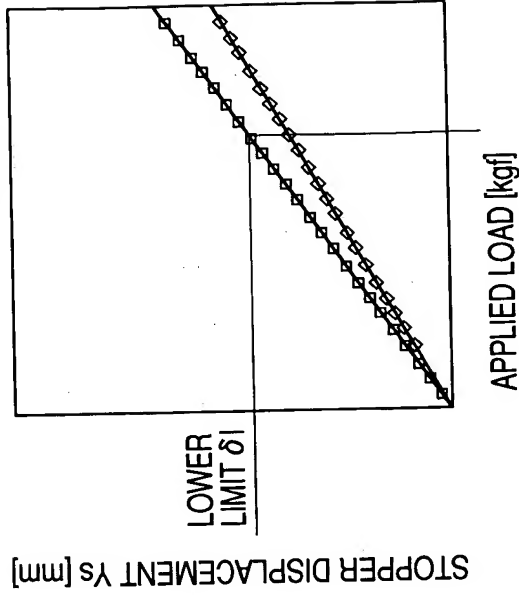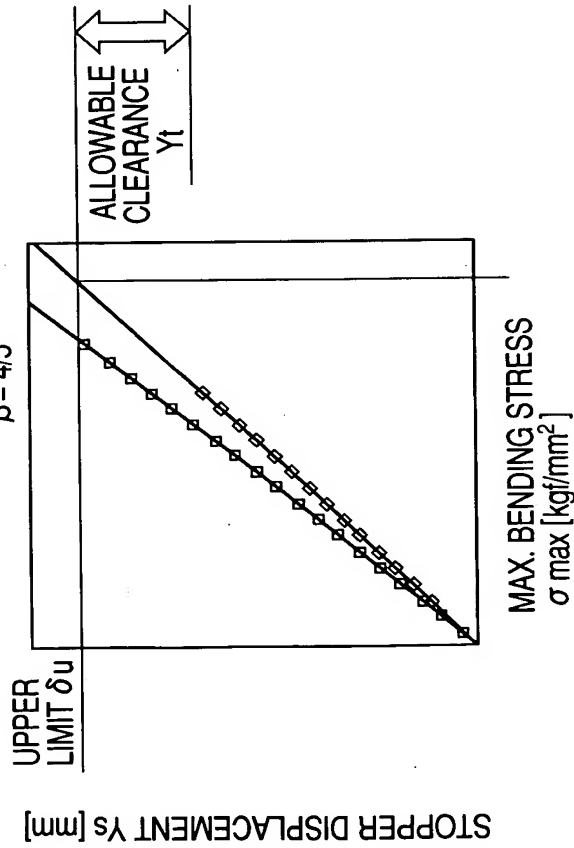STOPPER DISPLACEMENT Ys [mm]

UPPER LIMIT δu

ALLOWABLE CLEARANCE Yt

MAX. BENDING STRESS σ max [kgf/mm²]

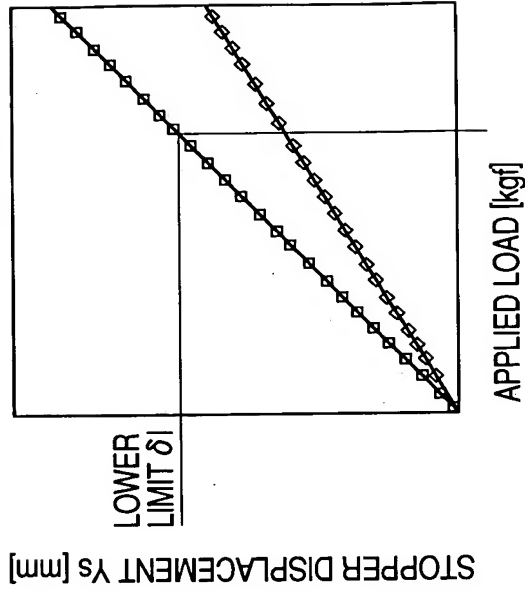$$\delta u = \frac{L^2}{3Et} \cdot \sigma e \cdots (6, 3)$$

$$\delta u - \delta l = Yt = \frac{L^2}{3Et} \cdot \sigma e - \frac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \cdots (10)$$
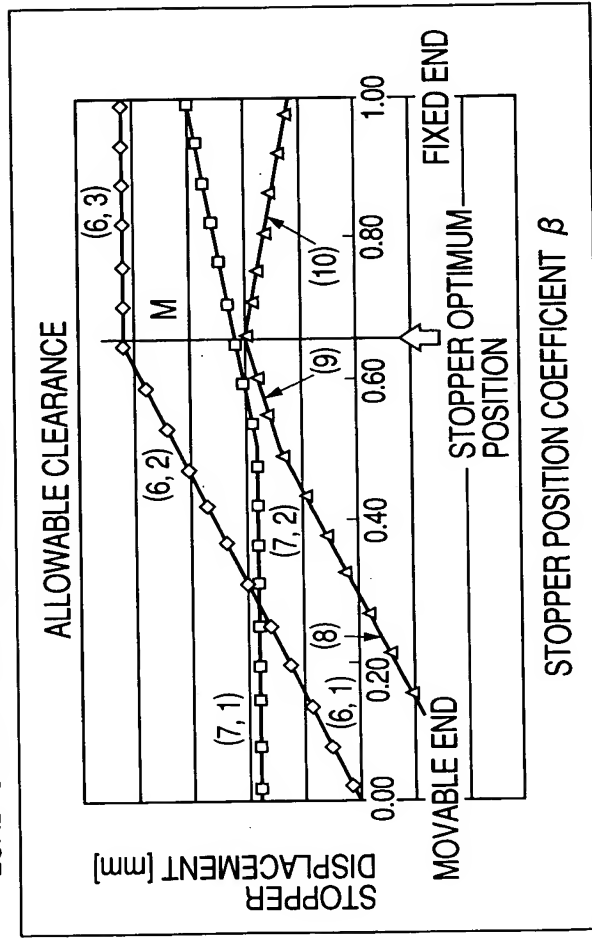
δl = STRESS LIMIT

FIG. 13(b)

$\beta = 4/5$

STOPPER DISPLACEMENT Ys [mm]

LOWER LIMIT δl

APPLIED LOAD [kgf]

$$\delta l = \frac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \cdots (7, 3)$$

W1 = LOWEST LOAD IN LOAD MEASUREMENT RANGE

FIG. 14

STOPPER OPTIMUM POSITION FOR REAR SENSOR INSTALLED
IN SAME DIRECTIONAL FORWARD ORIENTATION WHEN OFFSET
LOAD IS APPLIED TO FIXED END SIDE

◇ UPPER LIMIT δu
□ LOWER LIMIT δl
△ ALLOWABLE CLEARANCE Y_t
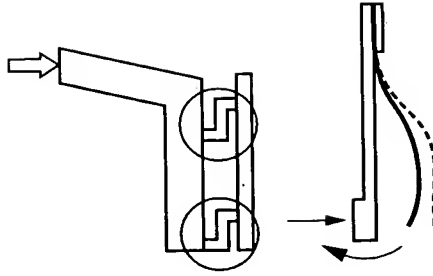
$$Y_t = \frac{L^2}{2Et} \cdot \sigma e \cdot \beta - \frac{L^3 \cdot W1}{Ebt^3} \quad \cdots (8)$$

$$Y_t = \frac{L^2}{2Et} \cdot \beta \cdot \sigma e - \frac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \quad \cdots (9)$$

$$Y_t = \frac{L^2}{3Et} \cdot \sigma e - \frac{2L^3 \cdot \beta \cdot W1}{Ebt^3} \quad \cdots (10)$$
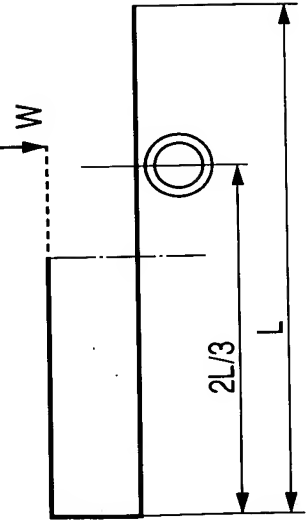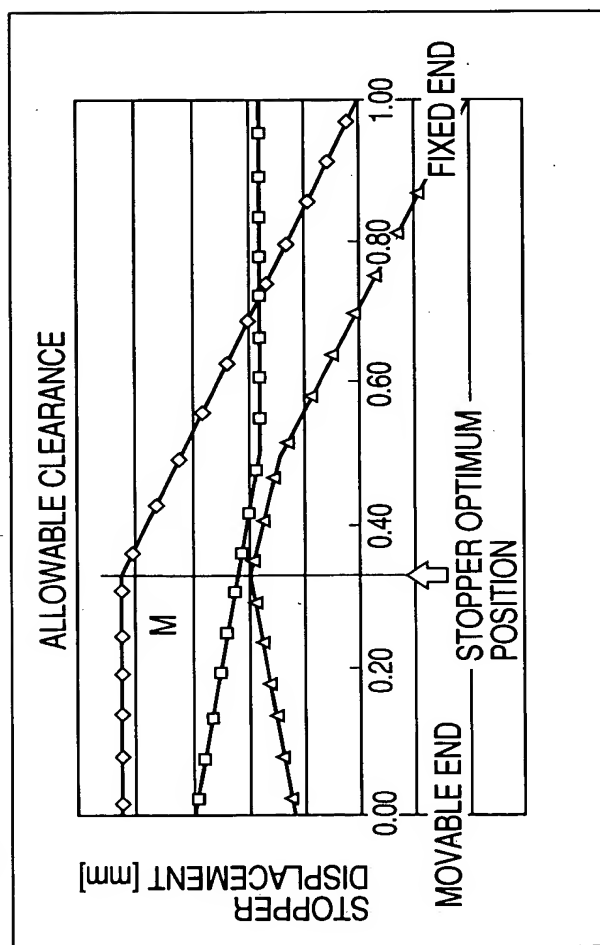
ALLOWABLE CLEARANCE

STOPPER DISPLACEMENT [mm]

MOVABLE END — FIXED END

STOPPER POSITION COEFFICIENT β

STOPPER OPTIMUM POSITION

(6, 3) M (6, 2) (7, 1) (6, 1) (7, 2) (8) (9) (10)

0.00 0.20 0.40 0.60 0.80 1.00

LOAD ON FIXED END SIDE

W

2L/3 L

FIG. 15

STOPPER OPTIMUM POSITION FOR FRONT SENSOR INSTALLED
IN SAME DIRECTIONAL FRONTWARD ORIENTATION WHEN OFFSET
LOAD IS APPLIED TO MOVABLE END SIDE

◇ — UPPER LIMIT δu
□ — LOWER LIMIT δl
△ — ALLOWABLE CLEARANCE Yt

FRONT SENSOR IS
DIFFERENT IN BENDING
MODE FROM REAR
SENSOR